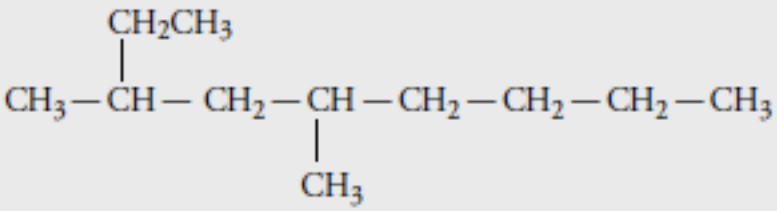
Student Textbook pages 620–623

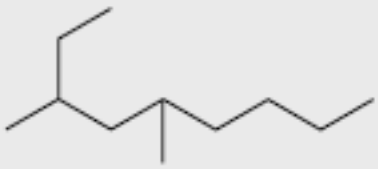
Answers to Understanding Concepts Questions

1. Carbon has four bonding electrons, which allow the formation of four strong covalent bonds to a variety of different atoms. In addition, carbon can form single, double, and triple covalent bonds with other carbon atoms to produce stable chains and networks of atoms.
2. Historically, an organic compound was defined as being formed by a living organism. The key idea behind this was that living organisms had some mysterious "vital force" that gave them the unique ability to produce organic compounds
3. The synthesis of organic compounds such as urea and acetic acid from inorganic starting materials required scientists to abandon the concept of "vital force."

4. Organic compounds are those in which carbon atoms are nearly always bonded to each other, to hydrogen atoms, and often to atoms of other elements.
5. **(a)** The condensed structural formula is



(b) The line structural formula is



(c) The empirical molecular formula is $C_{11}H_{24}$

(d) The expanded molecular formula is

$CH_3CH(CH_2CH_3)CH_2CH(CH_3)CH_2CH_2CH_2CH_3$

6. Each of compounds are aliphatic hydrocarbons.

(a) 3,4-dimethylheptane

(b) 4-methylheptane

(c) 2,2-dimethylpropane

(d) 1-ethyl-2-methylcyclohexane

7. (a) 3-ethyl-4-methylhex-1-ene

(b) 3-methylcyclopentene

(c) ethylbenzene

(d) 3-methylpent-1-ene

8. (a) substituted alkene

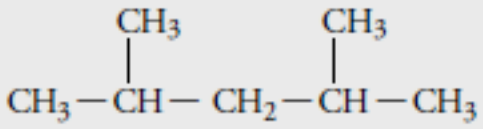
(b) substituted cycloalkene

(c) substituted aromatic

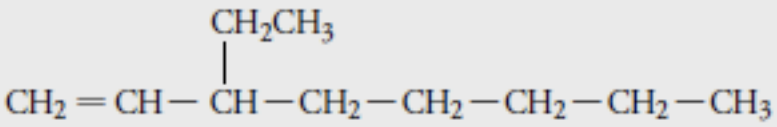
(d) substituted alkyne

9. The electrons that make up the second bond in each double bond of benzene are not just shared by the two adjacent carbon atoms but are shared equally among all six carbons. Electrons that behave in this way are called *delocalized electrons.* The circle indicates delocalized electrons.

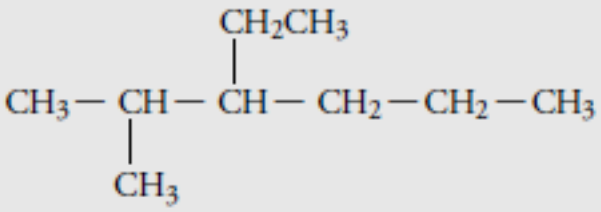
10. (a) 2,4-dimethylpentane



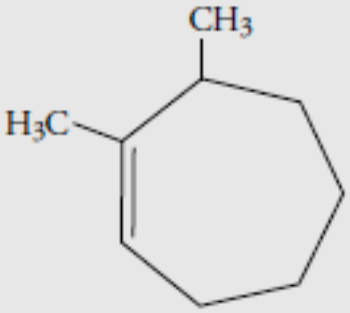
(b) 3-ethyloct-1-ene



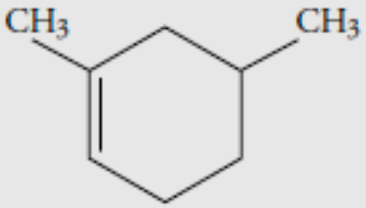
(c) 3-ethyl-2-methylhexane



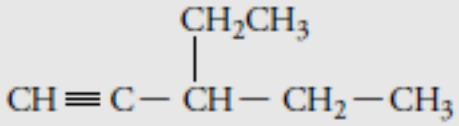
(d) 2,3-dimethylcycloheptene



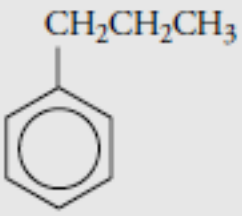
(e) 2,4-dimethylcyclohexene



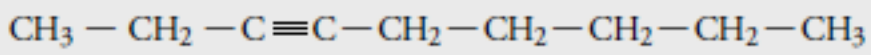
(f) 3-ethylpenty-1-ne



(g) propylbenzene



(h) non-3-yne



11. (a) carboxylic acid (carbonyl group): 5-methyloctanoic acid

(b) alcohol (carboxyl group): 5-ethyl-3-methyloctan-2-ol

(c) alkyl halide (halogen): 3-chloropentane

(d) alkyl halide (halogen): 2-bromo-4-methylpentane

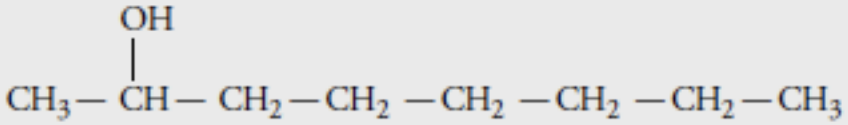
(e) alcohol (carboxyl): butan-2-ol

(f) ester: methyl butanoate

(g) ester: methyl 3-methylbutanoate

(h) alkyl halide (halogen): 3-bromo-2-chloro-4-fluorohexane

12. (a)



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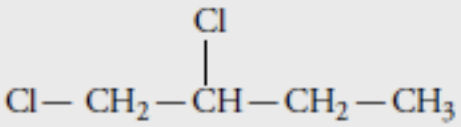

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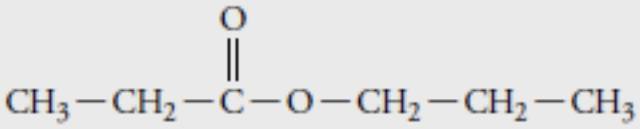
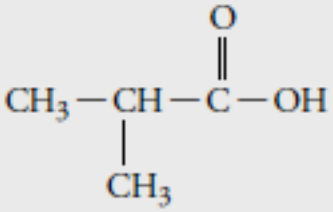
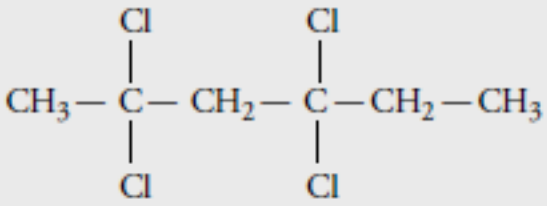


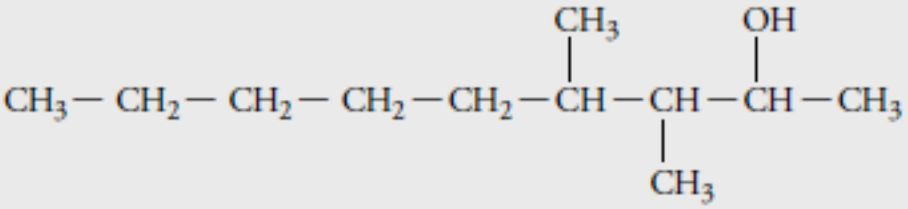
(d)



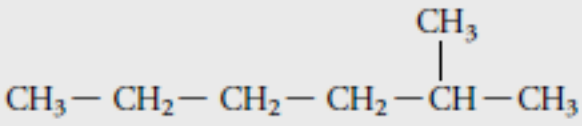
(e)



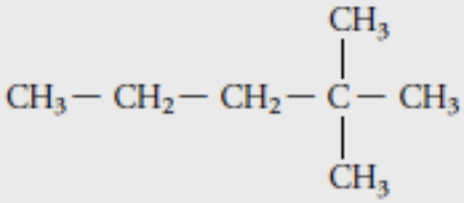
(f)



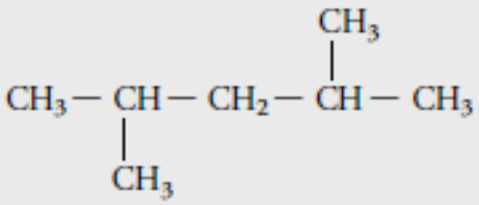
13. Three isomers that have the empirical formula, C_7H_{16} are:



2-methylhexane



2,2-dimethylpentane



2,4-dimethylpentane

14. Fractional distillation involves successive heating, evapouration, cooling, and condensation. Hydrocarbon components, called fractions, have a range of boiling points and relative densities. Separation of these fractions can be performed by heating. Fractions vapourize, rise upward in the tower, and condense onto plates placed at strategic locations where the temperature is just below the boiling point of a particular fraction.

15. **(a)** $CH_3CH_2CHICHICH_3$

(b) $CH_3CH_2CH_2Cl + HOH$

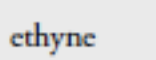
(c) propyl methanoate + water

(d) hept-1-ene + water

(e) $CH_3CHClCH_2CH_2Cl + HOH$

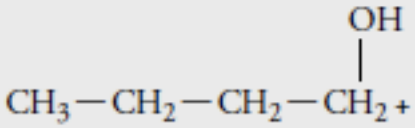
(f) $CH_3C(CH_3)CH_2 + NaBr + HOCH_2CH_3$

16. **(a)**

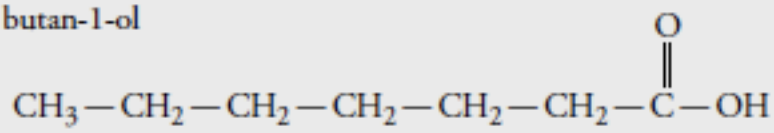


ethyne

(b)



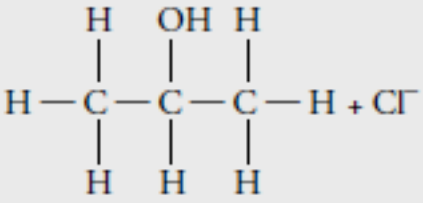
butan-1-ol



heptanoic acid

(c) $CH_2=CH-CH_3 + H_2$ (with platinum catalyst)

17. (a) propene hydrogen gas



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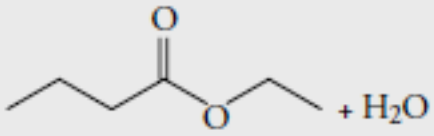
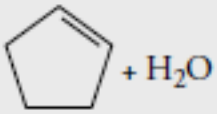


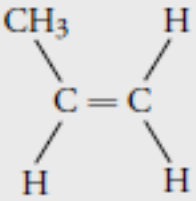
(c)



(d) $BrCH_2CH_2CH_2CH_2CH_3 + H_2O$

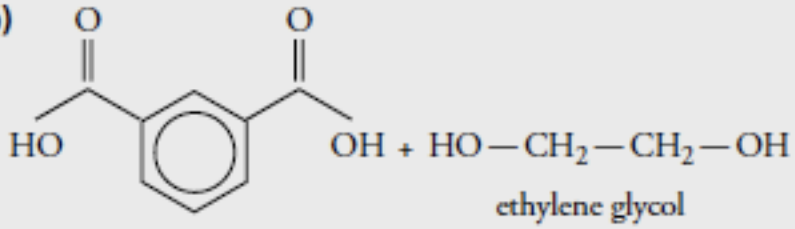
18. The monomers are:

(a)



propene

(b)



ethylene glycol

terephthalic acid

19. For A addition polymerization occurred. For B condensation polymerization occured.

20. (a) addition

(b) condensation

Answers to Applying Concepts Questions

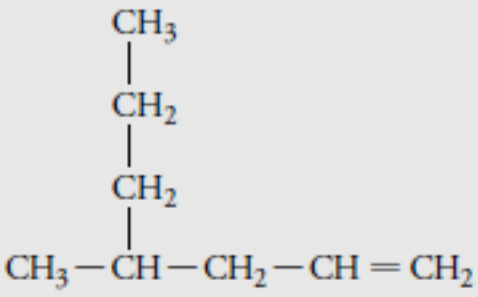
21. The alkane has 12 hydrogen atoms. The general equation for an alkane is C_nH_{2n+2}

22. The alkyne has 7 carbon atoms. The general equation for an alkyne is C_nH_{2n-2}.

23. The simplest test to distinguish between the two would be a piece of litmus paper. The carboxylic acid would turn blue litmus red. Alternately, boiling point determination would also allow for identification since the boiling point of pentanoic acid is higher than that for pentan-1-ol.

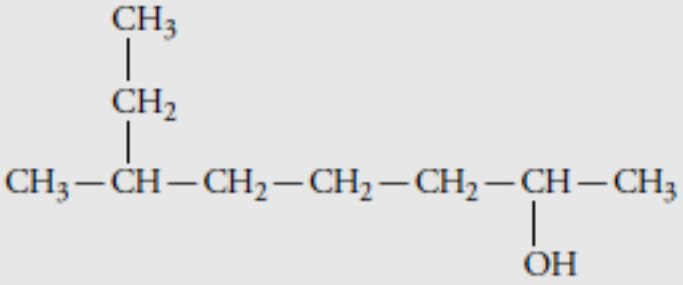
24. The correct names and structures are as follows:

(a)



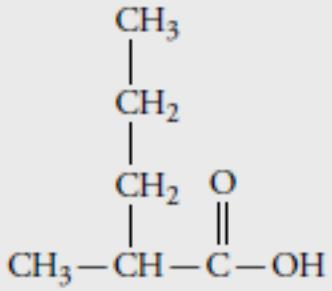
4-methylhept-1-ene

(b)



6-methyloctan-2-ol

(c)



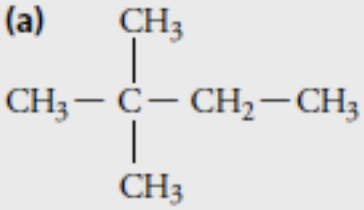
2-methylpentanoic acid

25. Structural isomers have the same molecular formula but different structural formulas. (a) and (f) are structural isomers; (c) and (e) are also structural isomers.

26. The alcohol will dissolve in water and has a characteristic sharp odour that will easily separate it from the other two compounds. Both hex-2-ene and benzene are non-polar and will have similar boiling points. Hex-2-ene is much more reactive than benzene and will undergo an addition reaction in the presence of aqueous bromine. The bromine solution, which is originally brown, will become lighter or colourless as the bromine is consumed (see ChemistryFile page 590).

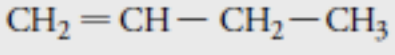
27. In each case the number of bonds to carbon was incorrect. Correct structures and names are as follows. Student answers may depend on how they decide to reduce the bond order.

(a)



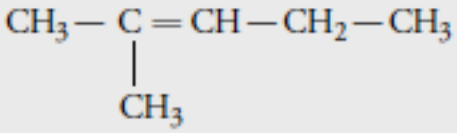
2.2-dimethylbutane

(b)



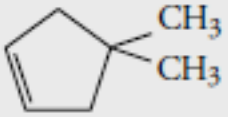
but-1-ene

(c)



2-methylpent-2-ene

(d)



4,4-dimethylcyclopentene

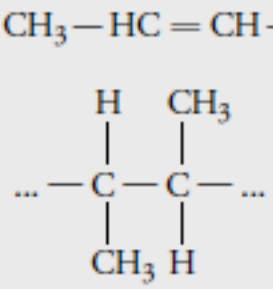
28. In an addition reaction a small molecule is added across a double or triple carbon-carbon bond. In a substitution reaction a hydrogen atom or functional group is replaced by another functional group.

29. To form a polyester the monomers being combined must have two functional groups – one at each end of the molecule. For one of the monomers this will be a carboxyl group, for the other this will be a hydroxyl group.

30. The mixing of chloroethane and sodium hydroxide will produce ethanol and sodium chloride in a substitution reaction. The reaction of ethanol and propanoic acid, with heating and the addition of a strong acid will produce the ester ethyl propanoate and water.

31. Monomer (top)

Polymer (bottom)



Procedure:

1. Dissolve the but-2-ene in a non-polar solvent such as mineral oil.
2. Add the catalyst and heat the solution to begin polymerization

Safety Precautions:

- But-2-ene is a gas at room temperature, is mildly toxic and highly flammable. Keep away from open flame. The gas will be stored under pressure and may explode when heated.
- Mineral oil and the polymer formed are both flammable.

Answers to Making Connections Questions

32. (a) fractional distillation

(b) crude oil

(c) bubble cap—it diverts rising vapours from below, increasing the efficiency of capture

(d) Steam enters at F, heating the crude oil so that many of the components vapourize

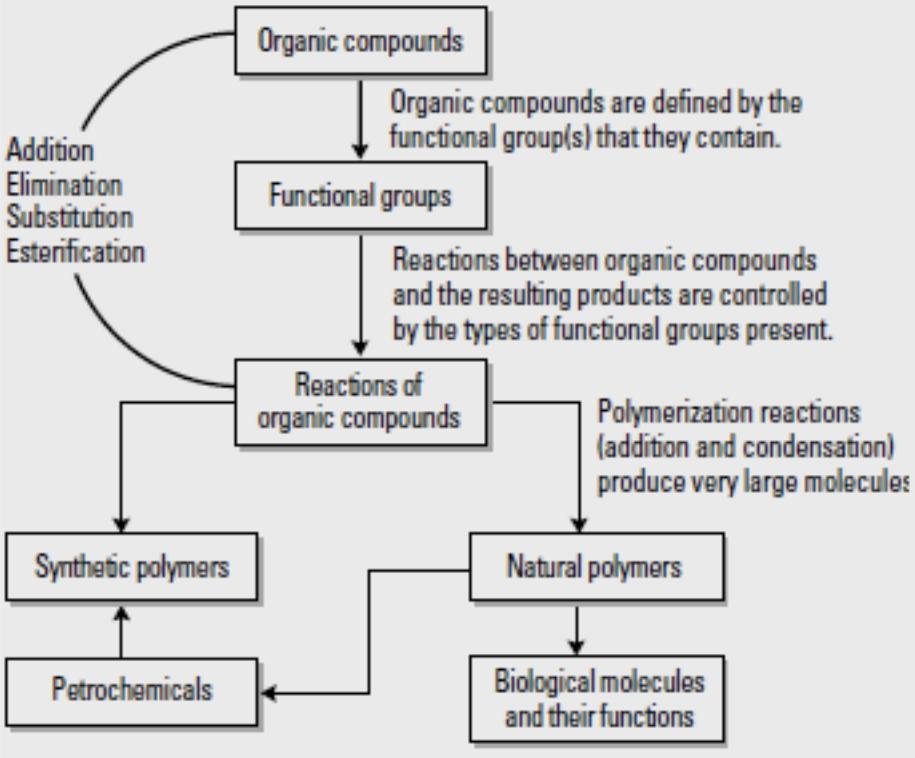
(e) Compounds containing more than 20 carbon atoms, which do not vapourize, exit at E

(f) The substances that exit from A to G are mixtures of hydrocarbons, with the shortest chain mixtures at the top (at A), and the longer chains (up to 20 carbons) exiting at E.

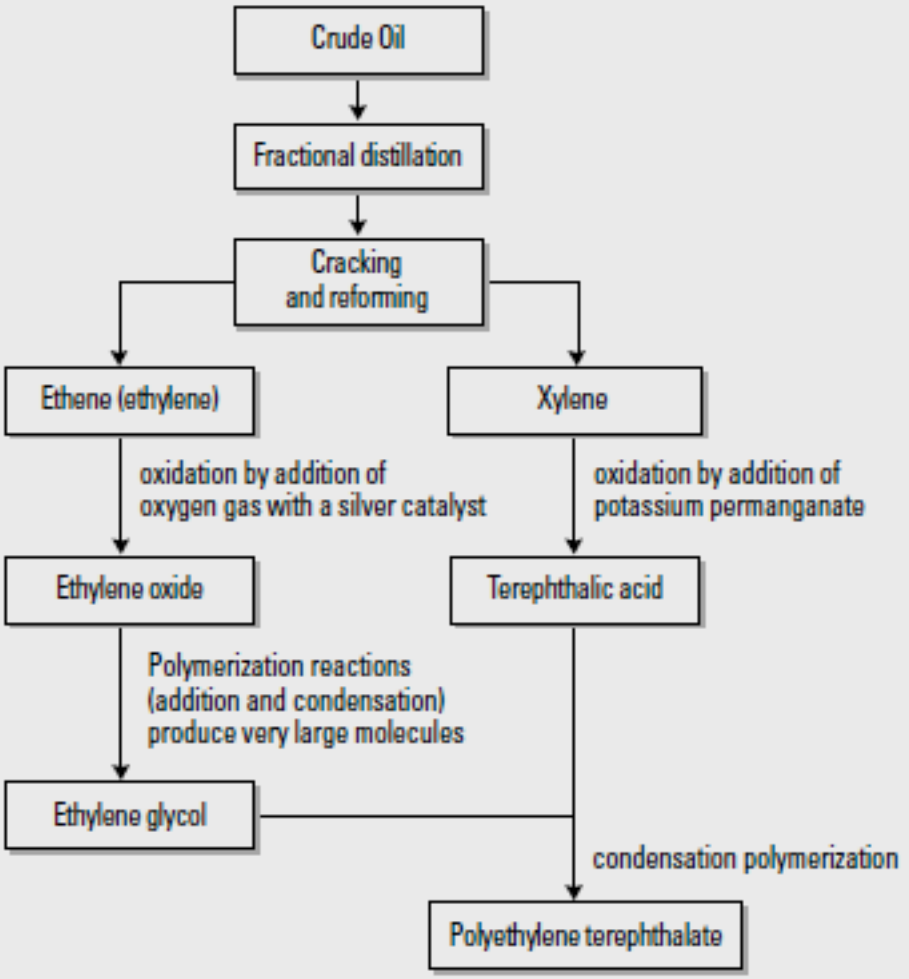
(g) The shorter the carbon chain, the weaker the intermolecular bonds holding the molecules together, therefore the lower the boiling point. Substances are collected based on their boiling points. The lower the boiling point, the higher they will collect in the tower, as they are collected when they condense. The substances with higher boiling points will condense lower in the tower.

33. Student answers will reflect the fact that the impact of organic compounds on health and lifestyle is so enormous. Every aspect of modern life is filled with uses, and sometimes abuses, of organic compounds. Examples could include pharmaceuticals, food additives, plastics and other polymers, and various types of fuels.

34. Student responses (and the amount of detail) will depend on how they perceived their learning process. One sample that a student may conceive of is shown below. The amount of detail will vary from one concept map to another.


Organic compounds
Organic compounds are defined by the functional group(s) that they contain.
Functional groups
Reactions between organic compounds and the resulting products are controlled by the types of functional groups present.
Reactions of organic compounds
Addition
Elimination
Substitution
Esterification
Polymerization reactions (addition and condensation) produce very large molecules
Synthetic polymers
Natural polymers
Petrochemicals
Biological molecules and their functions

35. One possible flowchart is illustrated below.



36. Student answers will likely include some of the following points. The public often believes that "natural" is safer and better than "synthetic," even if the compounds are identical. This is evident in natural and artificial flavourings, and with natural and artificial sweeteners. The public is prepared to pay a premium for "organic" or "natural" products, without knowing or understanding the differences between them. In order for consumers to make informed product choices, they have to thoroughly research the differences between the products. Many manufactured products have strict guidelines around labelling, while there are few if any guidelines around "natural" products.